

Digital Peers to Help Children's Text Comprehension and Perceptions

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ABSTRACT

Affable Reading Tutor (ART) is an online reading lesson designed for children who are starting to comprehend reading. A digital, human-like character (virtual peer) in ART serves as a peer model that demonstrates the use of the reading comprehension strategy called *questioning* to help improve the learners' comprehension of expository texts. This study, with 141 boys and girls in the fourth and fifth grades in the United States, examined the effects of virtual-peer presence (presence, absence, and control) on learners' text comprehension and also the effects of learner gender and virtual-peer attributes (human-like male, human-like female, robot still image) on learners' perceptions of their peer and on their text comprehension. The results revealed that the virtual-peer presence group outperformed both the absence group and the control group in the immediate and delayed posttests text comprehension. There were mixed results in the impacts of learner gender and virtual-peer attributes on text comprehension. The learners' perceptions of their agent were not differentiated by neither learner gender nor virtual-peer attributes. The findings are discussed with virtual-peer design implications.

Keywords

Interactive learning environment, Virtual peers, Pedagogical agents, Computer-assisted language learning, Reading strategy instruction

Introduction

Researchers in literacy education argue that social interaction fosters students' comprehension of texts while they are reading. That is, personal connection with peers and teachers enhances students' curiosity towards reading, their engagement in reading, and their preference for reading challenge (Guthrie, 2002). At the same time, the National Reading Panel in the United States (National Reading Panel, 2000) has issued a strong recommendation that young readers be directly taught reading strategies to increase their comprehension of expository texts.

Children at the early stages of reading to comprehend seem to need more direct individualized instruction and guidance through supportive relationships. This type of individual support, however, has been a big challenge in a conventional classroom setting, which typically has one teacher and dozens of children. As an alternative, computer-assisted language learning (CALL) might be explored as a way to provide young learners with direct and self-paced strategy instruction. With recent advances in interface technology, in particular, it is possible to simulate social and affective interactions in CALL, through animated digital peers or tutors (Kim & Wei, 2011; McQuiggan, Robinson, & Lester, 2010). The author developed Affable Reading Tutor (ART), a CALL environment embedded with a digital peer, to help elementary-school students learn questioning strategy to comprehend cause-and-effect relationships in expository texts. This paper presents a classroom-based experiment that has examined the effectiveness of peer presence on learners' text comprehension and their perceptions of their peer in ART.

Theoretical Backgrounds

Effective reading comprehension instruction

Social interaction is considered critical in learning and intellectual development. In particular, reading researchers have established that social interactions with peers and teachers can foster motivation to read and enhance text comprehension (Palinscar & Brown, 1984; Gambrell, 2001; Guthrie, 2002). Guthrie (2002) argues that situational interest is easily aroused in a shared reading context where individuals naturally expand themselves through interaction with their peers and teachers. Traditionally, well-known reading-comprehension instruction approaches like reciprocal teaching (Spörera, Brunsteina, & Kieschke, 2009), interactive read-aloud (Barrentine, 1996), dialogical-thinking reading lessons (Commeyras, 1993), and guided reading (Pinnell, 2002) are all interactive in nature and emphasize the provision of social context for enhanced engagement in reading and comprehension.

In addition, children who start reading to comprehend expository texts are very likely to benefit from direct, self-paced strategy instruction that helps them grapple with new texts (Almasi, Garas-York, & Shanahan, 2006; Guthrie et al., 2004; Leopold & Leutner, 2012; Pressley, 2002). For many young readers, reading comprehension strategies are not acquired naturally; rather, strategy use is a specific and learned procedure that promotes active and intentional reading (Trabasso & Bouchard, 2002). Readers who are not explicitly taught this cognitive procedure are less likely to learn, develop, or use the strategies spontaneously (Andreassena & Bråtenb, 2011; Wharton-McDonald, Pressley, & Hampston, 1998). Reading comprehension strategy, therefore, must be taught by way of direct instruction that uses explicit and repeated demonstration and modeling of strategy use (National Reading Panel, 2000). Moreover, it seems that a young reader benefits from individualized guidance, with which he/she can learn at his/her own pace to build the habit of strategy use gradually. One challenge is that this kind of individualized and direct strategy instruction is not always offered in conventional classrooms due to limited resources (i.e., a single teacher with a multitude of children) (Pearson & Dole, 1987). One promising area to explore could be work done in computer-assisted language learning.

Computer-Assisted Language Learning (CALL)

In recent decades, CALL researchers have explored a range of technologies and pedagogical approaches such as interface design and authoring, data management and access, intelligent tutoring systems, speech recognition technologies, and natural language (Stockwell, 2007). The areas most extensively studied in CALL research over time include grammar, vocabulary, speaking, and writing. Also, CALL has been applied and studied more actively in the context of second-language learning than in first-language learning. For example, in a study with 122 Korean tenth-graders who learn English as a foreign language, Yun and colleagues (2008) found that constructed-response (fill-in-the-blank) questions with explicit feedback in CALL were effective for improving the learners' recall of vocabulary and transfer. Chen and Wang (2008) tested several of Ellis's language learning principles in collaborative cyber-community-based learning, with seven Chinese EFL learners in a college and found that the use of text chat and joint web browsing helped foster communicative language skills in synchronous online classes.

In contrast to the growing amount of CALL research, the use of CALL to teach reading has been relatively limited and has even shown a consistently decreasing trend over the last decade (Stockwell, 2007). Furthermore, among the existent CALL applications for reading, the majority deals with discrete skills development like vocabulary building and word recognition. A meta-analysis of CALL research in reading indicates that most research has focused on developing phonemic awareness, letter identification, word identification, and speed and fluency in reading words (Blok, Oostdam, Otter, & Overmaat, 2002). There has been a dearth of CALL research to examine the effectiveness of CALL for reading comprehension instruction. Reading comprehension could be better taught in social and interactive contexts, as recommended by many reading researchers.

Although CALL applications afford individualized instruction conventionally, they often fall short of integrating social interaction. Therefore, the author explored animated, digital peer technology to see if the technology would expand the capacity of CALL by rendering a social context that might benefit young readers.

Virtual peer

The term virtual peer refers to an animated, digital character, a subset of a more broadly used term *pedagogical agents* (animated life-like characters embedded in educational applications). It is well acknowledged that people, consciously or unconsciously, tend to ascribe mental states to computers and interact with computers socially (Kim, 2007; Reeves & Nass, 1996). Virtual peer technology seems to broaden the communication bandwidth between a learner and a computer. It has been used to render social presence and enrich learning experiences in computer-based learning (Gulz, 2005; Iacobelli & Cassell, 2007; Johnson, Rickel, & Lester, 2000). A number of researchers in pedagogical agents support consistently that the social presence produces positive gains in learner affect and engagement (Atkinson, 2002; Dempsey & van Eck, 2003; Gulz, 2004; Johnson, et al., 2000; Kim & Wei, 2011; Mayer, Johnson, Shaw, & Sandhu, 2006; Moreno & Mayer, 2000; Plant, Baylor, Doerr, & Rosenberg-Kima, 2009). Moreover, some studies argue for the modeling effect (Kim & Baylor, 2007; Ryokai, Vaucelle, & Cassell, 2003). Kim and Baylor (2007) claimed that the use of virtual peers as role models for learners could be viable for enhanced motivation and learning, in that a virtual peer playing as a coping or mastery model could motivate the learner toward challenging and less popular domains of learning.

Embedded in computer-based reading instruction, a virtual peer could be designed to explicitly demonstrate reading strategy use and encourage a young reader to use the strategy. Through the peer's modeling (Bandura, 2001; Schunk & Hanson, 1989), the learner might vicariously learn the strategy use and improve their text comprehension. Further, the peer's visual and verbal demonstration is likely to lessen young readers' burden to read through explanations in text or graphics (i.e., reducing cognitive load) and, thereby, improve the efficacy of strategy instruction. Ryokai and colleagues' study (2003) hinted this modeling effect. In their study, children who played with the virtual peer *Sam* listened to Sam's stories carefully and mimicked Sam's linguistic styles in their speech. It seemed that Sam played a social role for the children. The children might feel affiliated with Sam, which, presumably, induced their behavioral changes. A similar modeling impact was implied in an online tutoring game teaching phonemic decoding skills, where children's skills increased only when the program included a digital tutor that gave oral feedback to the children (Kegel & Bus, 2012).

Given the lack of computer-based reading-comprehension instruction, the author developed a reading lesson, Affable Reading Tutor (ART) to model the use of comprehension strategy for children who just started reading to comprehend. In the lesson, the children studied finding cause-and-effect relationship in expository texts, observing a virtual peer's strategy use. The young readers might be able to develop social relations and interact socially with the peer, which would be beneficial for their motivation and text comprehension. The author investigated the impact of the peer serving as a peer model that demonstrated strategy use to increase the learners' text comprehension.

This study was focused on how effectively a virtual peer's modeling of reading strategy use would improve children's text comprehension, compared to the strategy instruction without virtual-peer presence. The primary research question asked 1) *Will the presence of a virtual peer influence learners' text comprehension?* Also, referring to the current literature in virtual peers (or pedagogical agents), two additional questions were asked. The second question was about learner gender because learner gender was often a factor determining the effectiveness of agent presence (Baylor & Kim, 2005; Kim, Baylor, & Shen, 2007). The second question asked 2) *Will learner gender and virtual-peer presence interact to influence text comprehension?* The third question was about learners' perceptions of virtual-peer attributes. Researchers in agent technology emphasize a learner's building social relations with their agent in order to maximize its instructional effectiveness (Dautenhahn, Bond, Canamero, & Edmonds, 2002). How a learner would perceive their virtual peer seems to be a meaningful factor for the efficacy of the learning environment. At the same time, much of agent research indicates learners' sensitive reactions to agent attributes, such as gender and appearance (Baylor & Plant, 2005; Haake & Gulz, 2008; Kim, Wei, Xu, & Ko, 2007). In particular, Haake and Gulz (2008) argue that an agent's visual appearance carries social baggage that could activate a learner's expectations of the agent. The third question asked 3) *Will learner gender and virtual-peer attributes interact to influence learners' perceptions of a virtual peer?*

Method

Participants

Participants were 141 children in the fourth and fifth grades (68 boys and 73 girls) in an elementary school located in a mountain-west state in the United States. Access to the participants was achieved by collaborating with classroom teachers who volunteered to use the intervention environment in their classes. The study was implemented as a mandatory class activity. The participants were randomly assigned to experimental conditions by the system programming.

Learning environment

Curriculum content

The intervention was an online strategy lesson named Affable Reading Tutor (ART), which was delivered via the Internet. The curriculum included reading comprehension of science texts, combining language arts and science education in keeping with the Benchmarks for Science Literacy set by the American Association for the Advancement of Science (<http://www.aaas.org>) in the USA. Comprehending expository texts is challenging because of the texts' abstract nature and complicated and varied sentence structures (Gersten, Fuchs, Williams, & Baker, 2001). It is particularly difficult for young learners, whose limited background knowledge inhibits their ability to inferentially connect ideas into a coherent

mental representation of the texts (Cote, 1998; McNamara & Kintsch, 1996). Reading strategy must be taught directly to assist those learners.

The specific content identified cause-and-effect relationships using questioning strategy. Questioning strategy was chosen because it was most broadly recommended in the literature on reading strategy instruction (Cerdána, Vidal-Abarcab, Martínezb, Gilabertb, & Gilb, 2009; Rosenshine, 1986; Spörera, et al., 2009). The National Institute for Literacy (2007) highlights questioning strategy as a way to support struggling readers in the publication *What Content-Area Teachers Should Know About Adolescent Literacy*. To deal with expository texts, readers should “generate questions before, during, and after reading . . . (p. 20).” Questioning thoughtfully while reading helps a reader to gain more information from unfamiliar texts.

In the ART lesson, children read a story about a boy named Ian who set up a weekly training schedule to condition himself to run a marathon. The virtual peer, Chris, demonstrated the questioning strategy and encouraged the learners to use the strategy. Before the learners started reading, Chris explained both cause and effect and how to use the questioning strategy to find the cause-and-effect relationship in sentences. During the reading, Chris demonstrated using the strategy by asking the learners questions about what they have read. He also presented verbal encouragement for the learners to build a habit of questioning while reading. The learners practised identifying causes and effects, guided by Chris’s questioning. The practice problems were presented in different formats, e.g., multiple choice, short answer, and open-ended.

Based on the literature (Guthrie, Wigfield, & Humenick, 2006; van Keer & Verhaeghe, 2005), the author developed Chris’s questions in seven categories: (1) Questions to activate students’ prior knowledge: e.g., *Do you like sports? What’s your favorite sport?* (2) Summarizing questions: e.g., *If you were to summarize the first paragraph in one or two sentences, what information would you include?* (3) Direct questions: e.g., *Why does Ian need regularly scheduled days of rest? What will happen if Ian doesn’t rest his muscles and joints?* (4) Questions to guide writing: e.g., *If you could exercise regularly, what kind of exercise would you do? Why?* (5) Comprehension questions: e.g., *If you can make a title for the story, what would you choose for the title?* (6) Inference questions: e.g., *What would happen if Ian didn’t practise running before he runs a marathon?* (7) Inferential-comprehension questions: e.g., *What is this passage mainly about?* Figure 1 presents example screens of the ART environment, with two variations of Chris (male and female) and without Chris (a still image of a robot as a space filler).



Figure 1. Virtual peer variations in ART

Virtual peer design

Male and female peer images were designed using Curious Labs’ Poser, as shown in Figure 1. Voices of a similar-aged boy and girl were recorded and synchronized with the images. To stimulate a learner’s sense of being related to the virtual peer, the talking style was matched with the target learner group’s style. Facial expressions, blinking, and pointing gestures were added to make Chris look believable and natural.

Independent variables

Virtual-peer presence

Virtual-peer presence had three levels (presence, absence, and control). In Presence, a peer (either male or female, randomly assigned) was present. In absence, students worked in ART without a peer. Instead, a still image of a robot filled the space, and a computer-generated voice-over presented instructional messages. The control group did not take ART and performed the learning task individually with paper-based material. This material presented exactly the same strategy instruction in text and graphics, without a virtual-peer image. Except for the described differences, all three conditions presented the identical instructional content.

Learner gender

Based on the previous agent studies and the preliminary interviews with boys and girls from the target group, learner gender (male versus female) was included as a variable to understand if there would be gender differences in text comprehension and in student perceptions of a virtual peer (research questions 2 and 3).

Virtual-peer attributes

There were three virtual-peer attributes (human-like male, human-like female, and robot image).

Dependent measures

Text comprehension

To measure the students' text comprehension, paper-based pre- and posttests were administered. The pretest included six short-answer questions about a passage on Ian's sunburn after swimming at the beach, e.g., *What caused Ian's sunburn? What was the effect of the sunburn?* The test was administered the day before the intervention and later used as a covariate to control for learners' prior comprehension skills. Two posttests were implemented, one the day after the intervention (immediate posttest) and the other one week after the intervention (delayed posttest). In a short-answer format, each test asked two recall questions on the information presented in the intervention and eight comprehension questions (four questions per passage). Two recall questions asked (1) *What keywords help you identify a cause?* (2) *What keywords help you identify an effect?* Each was awarded three points. The comprehension questions were similar to the pretest. For example, in a passage about rainbows, students were asked questions such as the following: *Let's find the effect, what happens after rainbows occur? What causes the colors to arc across the sky?* The maximum possible score in a posttest was fourteen.

Perceptions of a virtual peer

Learners' perceptions of a virtual peer were measured by a fourteen-item questionnaire, modified from Agent Affability Measures (Kim, Baylor, et al., 2007; Kim, Wei, et al., 2007). At the end of the lesson, learners were asked to express the degree to which they agreed with each item, on a scale from 1 (not at all) to 7 (very much). The statements were as follows: (1) *Chris was friendly*, (2) *Chris was smart*, (3) *Chris was interesting*, (4) *Chris made me feel comfortable*, (5) *Chris was dependable*, (6) *Chris was intelligent*, (7) *Chris was easy to understand*, (8) *Chris was approachable*, (9) *Chris cared about my learning*, (10) *Chris made the lesson interesting*, (11) *Chris made me excited about reading*, (12) *Chris helped me understand better*, (13) *I felt like Chris understood me*, and (14) *I'd like to learn reading skills from Chris again*. Inter-item reliability, evaluated as Coefficient α , was .95.

Procedures

The researcher implemented the ART lesson, assisted by the teachers, to control for teacher influence. Both computer- and paper-based (control group) lessons were entirely self-contained. The learners completed all the tasks individually, depending solely on the information presented in the material. The overall procedures were as follows:

1. The children took a paper-based pretest a day prior to the intervention.
2. On the intervention day, they were randomly assigned to the groups and briefly introduced to the materials.
3. They performed the learning task for one class.
4. They took a paper-based posttest the day after the lesson and another posttest a week after the intervention.

Design and analysis

For research question 1, the independent variable was virtual-peer presence (agent presence, absence, and control), and the dependent variable was text comprehension. This question was answered using one-way ANCOVAs, with a pretest text comprehension set as a covariate, respectively for the immediate posttest and for the delayed posttest.

For research question 2, the independent variables were virtual-peer presence and learner gender (male vs. female), and the dependent variable was text comprehension. Question 2 was answered using two-way ANCOVAs, with a pretest set as a covariate, respectively for the immediate posttest and for the delayed posttest.

For question 3, the independent variables were virtual-peer attributes (human-like male, human-like female and robot image) and learner gender (male vs. female), and the dependent variable was learners' perceptions of their peer. Question 3 was answered using a two-way ANOVA. For all the analyses, the significance level was set at $\alpha < .05$.

Results

Table 1 presents the descriptive statistics of three text-comprehension tests. The pretest was analyzed using a one-way ANOVA, which revealed no statistically significant difference among the groups.

Table 1. Means and standard deviations of text comprehension tests

Tests	Peer presence	Peer absence	Control
Pretest	2.85 (1.12)	2.85 (1.35)	2.18 (1.18)
Immediate posttest	7.86 (.36)	6.36 (.62)	6.46 (.60)
Delayed posttest	8.65 (.23)	8.16 (.38)	7.26 (.35)

Research question 1: The effect of virtual peer presence on text comprehension

For the immediate posttest, the one-way ANCOVA revealed a significant main effect for virtual-peer presence, $F(2, 98) = 3.36$, $p < .05$, $\eta^2 = .06$ (a medium effect, according to Cohen's guidelines) (Cohen, 1988). The virtual-peer presence group outperformed the absence group and also the control group.

For the delayed posttest, the one-way ANCOVA revealed a significant main effect for virtual-peer presence, $F(2, 87) = 5.53$, $p < .01$. The effect size of this difference was evaluated as $\eta^2 = .11$, indicating a medium effect. The Bonferroni post hoc revealed that the virtual-peer presence group significantly outperformed the control group. In conclusion, both immediate and delayed posttests results supported the effectiveness of virtual-peer presence on learners' text comprehension.

Research question 2: The interaction effect of learner gender and peer presence on text comprehension

The two-way ANCOVA revealed neither statistically significant interaction of learner gender and virtual-peer presence nor main effect of learner gender on text comprehension in immediate and delayed posttests. However, as shown in Figure 2, a visual representation suggested an interaction trend that separated boys' and girls' text comprehension by virtual-peer conditions in the two tests. That is, girls' text comprehension was ranked in the order of virtual peer presence

highest, robot image next, and control least whereas boys' text comprehension was in the order of virtual peer (highest), then control, then robot image.

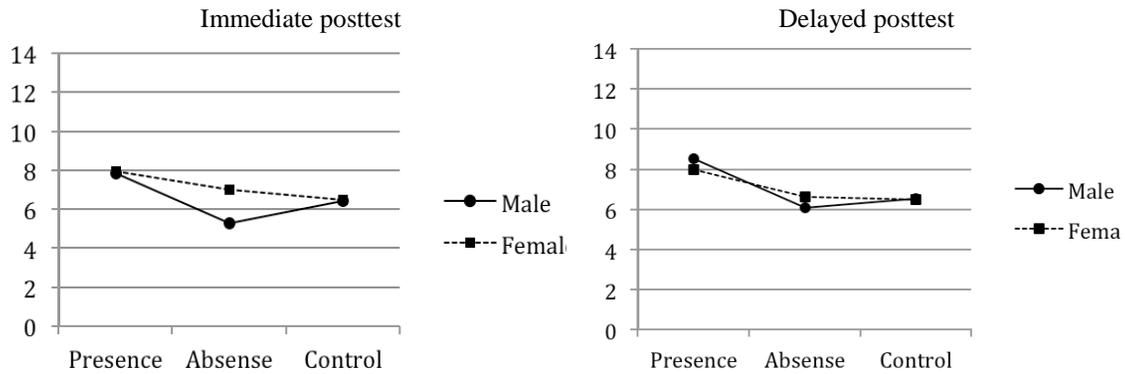


Figure 2. Text comprehension in the immediate posttest

Therefore, one-way ANCOVAs with boys and with girls separately were further conducted to examine statistical differences in each group's text comprehension by virtual-peer presence. The results revealed a significant difference only in the girls' text comprehension in the delayed posttest, $F(2, 46) = 3.62, p < .05$. The Bonferroni post hoc revealed that the girls in virtual peer presence significantly outperformed the control group. The effect size of this difference was evaluated as $\eta^2 = .14$, indicating a medium effect.

Research question 3: The effect of learner gender and peer attributes on peer perceptions

The two-way ANOVA revealed neither statistically significant interaction effects nor main effects of learner gender and virtual-peer attributes on learners' perceptions of their peers. However, a visual representation of the data suggested an interaction trend, as shown in Figure 3. Boys tended to perceive the robot image most favorably whereas girls perceived it least favorably. Therefore, one-way ANOVAs with boys and girls separately were further conducted to examine statistical differences in each group's perception of their peer by virtual-peer attributes. The results did not reveal statistical significance of virtual-peer attributes on the boys' perceptions of the agent nor on the girls' perceptions.

Incidentally, the author tested boys' and girls' text comprehension by virtual-peer attributes. The results revealed a significant difference on the boys' text comprehension in the immediate posttest, $F(2, 35) = 8.65, p < .001$. The effect size of this difference was evaluated as $\eta^2 = .33$, indicating a strong effect. The boys in the male-peer condition outperformed the female-peer group ($p < .001$) and also the robot image group ($p < .01$). This difference was not observed among the girls.

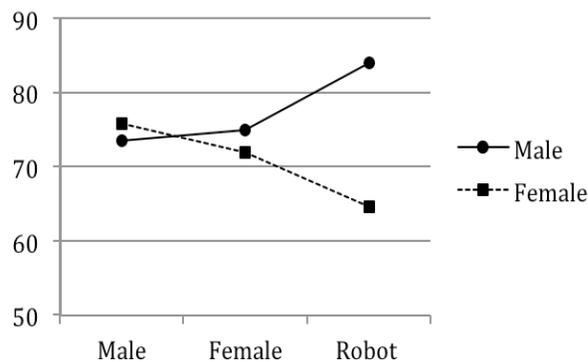


Figure 3. Learner perceptions of the virtual peer

Discussion

This study explored whether a virtual peer would be able to simulate the role of a peer model in conventional settings so as to effect computer-based reading-strategy instruction. Although direct and individualized reading strategy instruction is essential for children who start reading to comprehend, reading strategy instruction has not been actively applied in CALL. Also, some conventional reading programs present the concepts, examples, and strategies in text or at best in images. This manner of information presentation seems untenable, particularly for young readers who start reading to comprehend. First, children might be less engaged in learning reading strategies because of the impersonal nature of written texts presented on the screen. Text may not be sufficiently motivating to promote strategy use. Second, learners need constant reminders and encouragement to use the learned strategy. The author examined the use of the social and affective affordance of virtual-peer technology to provide more engaging strategy instruction for young children. The results of the study, in general, supported the benefit of virtual peer technology as a viable tool to offer effective strategy instruction in CALL.

Regarding the effectiveness of virtual-peer presence on text comprehension, the results supported the effectiveness of virtual-peer technology on learning. This study, implemented in natural classrooms, added evidence for the positive impact on learning gains that have been inconclusive in the virtual-peer (or pedagogical-agent) literature. A number of empirical studies in agent technology conducted over the last decade have supported agent technology's effectiveness on learner affect, including interest, motivation, attitudes, or engagement, with different age groups. There is a consensus among the researchers on the effectiveness of agent presence on learner affect and motivation. However, only a few studies have shown the effectiveness on learning gains (Atkinson, 2002; Graesser, Moreno, & Marineau, 2003; Moreno, Mayer, Spies, & Lester, 2001). In this study, the fourth- and fifth-grade boys and girls more effectively increased their comprehension of expository texts after working with a human-like virtual peer, compared to the peer absence groups. One reason is that the virtual peer might play a social role as a peer model to motivate the learners to engage. More important, the peer was equipped with solid pedagogy for strategy instruction recommended by the reading research community. Designers often seem to focus on maximizing the affordance of a technology and overlook the importance of content pedagogy. To be effective, however, technological affordance should be orchestrated integrally with subject-matter pedagogy. This might be analogous to a capable human teacher or peer in classroom. Teacher presence alone might not be sufficient to produce increased learning. The teacher must be well versed in the content and in pedagogical approaches to foster successful learning. Also, the social and affective dynamic seems to play a pivotal role in reading instruction for a learner's willingness to try. Just as the virtual peer's supportive demeanor might facilitate the learner's engagement, so do the supportive relationships with the teacher or peer help inspire a learner to read in a classroom.

Regarding the impact of learner gender, this study resulted in somewhat mixed findings. When both learner gender and virtual-peer presence were included in the analysis, there was no statistically significant gender difference. However, when the impact of peer presence was examined with boys only and with girls only, the results revealed different patterns of gender difference in text comprehension. The girls' text comprehension in the delayed posttest was significantly higher in the virtual-peer presence condition, compared to the peer-absence group, who used ART without a peer, and also to the control group, who used a paper-based material. The boys' text comprehension was significantly higher in the immediate posttest in the male-peer condition than the female-peer condition and the robot-image condition.

These findings seem to be in line with agent literature. First, female students show more positive attitudes toward agent presence and perform better after working with an agent or at computing applications supporting social interactions (Cooper & Weaver, 2003; Hakkarainen & Palonen, 2003; Kim et al., 2007; Passig & Levin, 2000; Weber & Custer, 2005). Second, studies revealed the superior effectiveness of a male agent to that of a female agent, regardless of learner gender (Baylor & Kim, 2004; Kim, Baylor, et al., 2007). The authors in these studies attributed the differential effectiveness to the influence of gender-related social biases (Carli, 1999, 2001). The current study revealed a similar pattern in learner and agent gender, but less strongly, possibly due to the developmental stage of the boys and girls. Literature in social psychology indicates that students over the age of thirteen are considered typically imbued with gender-related stereotypes (Dunham, 1990). The learners in this study did not seem to possess established gender-based biases for their learning, or perhaps these biases still remained at a subliminal level.

Debriefing with the learners also revealed a consistent pattern. The author asked the learners about their preferences for virtual-peer gender in future applications. Although several boys and girls articulated their preferences, the majority looked uninterested in the issue. This might also explain why the learners' perceptions of their peer were not differentiated by virtual-peer attributes, in contrast to previous agent studies with adolescents and college students.

Third, regarding the impact of virtual-peer attributes, the study did not produce sufficient evidence for the boys' and girls' differential reactions to virtual-peer attributes. This result might be related to the second point. The learners did not seem to have developed stereotypical expectations for agent appearance (Haake & Gulz, 2008). This age group might be at the stage where we can effectively intervene to prevent from undesirable gender- or race-related stereotypes, using agent technology. As Haake and Gulz suggested, virtual peers could be flexibly designed to have a range of identities and styles for educational purposes and counter negative social influences in the real world.

One thing to note is a trend that girls' perceptions of their virtual peer were ranked consistently with their learning gains. They perceived a human-like virtual peer—regardless of its gender—most favorably and comprehended text highest in the peer condition. On the other hand, boys' perceptions of the virtual peer were ranked opposite to their learning gains. The boys perceived a robot image with synthetic voice-over most favorably, but performed poorest in that condition. Perhaps the boys perceived the robot as fun, which, in turn, triggered a play mood and made the boys less serious about the learning task. Learners' readiness must be a consideration in the design of virtual-peer attributes. Careful analysis of learners, immediate and long-term learning goals, and learning contexts should be warranted prior to launching the design.

A few recommendations are made to expand and confirm the findings. First, subsequent research should examine learners' strategy use. The frequency of their strategy use in the following reading task will better inform us of the effectiveness of virtual-peer modeling and the relational bond between a learner and the peer. Second, it would be worth examining the relationship between fun learning experience and actual learning gains in technology-based learning (e.g., virtual-peer-based learning, simulations, and games). Third, the findings provide only initial evidence for the potential of a virtual peer for effective strategy instruction and should be generalized judiciously. Because virtual-peer technology was new to the learners, we cannot exclude the possibility of the novelty effect. Future research should confirm the finding over the long term.

References

- Almasi, J. F., Garas-York, K., & Shanahan, L. (2006). Qualitative research on text comprehension and the report of the National Reading Panel. *The Elementary School Journal*, *107*(1), 37–66.
- Andreassena, R., & Bråtenb, I. (2011). Implementation and effects of explicit reading comprehension instruction in fifth-grade classrooms. *Learning and Instruction*, *21*(4), 520–537.
- Atkinson, R. K. (2002). Optimizing learning from examples using animated pedagogical agents. *Journal of Educational Psychology*, *94*(2), 416–427.
- Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*, 1–26.
- Barrentine, S. J. (1996). Story time plus dialogue equals interactive read-alouds. In L. B. Gambrell & J. F. Almasi (Eds.), *Lively Discussions! Fostering Engaged Reading* (pp. 52–62). Newark, Delaware: International Reading Association.
- Baylor, A. L., & Kim, Y. (2005). Simulating instructional roles through pedagogical agents. *International Journal of Artificial Intelligence in Education*, *15*, 95–115.
- Baylor, A. L., & Plant, E. A. (2005). Pedagogical agents as social models for engineering: The influence of appearance on female choice. In C. K. Looi, G. McCalla, B. Bredeweg, & J. Breuker (Eds.), *Artificial intelligence in education: Supporting learning through intelligent and socially informed technology* (Vol. 125, pp. 65–72). Amsterdam, The Netherlands: IOS Press.
- Blok, H., Oostdam, R., Otter, M. E., & Overmaat, M. (2002). Computer-assisted instruction in support of beginning reading instruction: A review. *Review of Educational Research*, *72*(1), 101–130.
- Carli, L. L. (1999). Gender, interpersonal power, and social influence. *Journal of Social Issues*, *55*(1), 81–99.
- Carli, L. L. (2001). Gender and social influence. *Journal of Social Issues*, *57*(4), 725–741.
- Cerdána, R., Vidal-Abarcab, E., Martínezb, T., Gilabertb, R., & Gilb, L. (2009). Impact of question-answering tasks on search processes and reading comprehension. *Learning and Instruction* *19*(1), 13–27.
- Chen, N. S., & Wang, Y. (2008). Testing principles of language learning in a cyber face-to-face environment. *Educational Technology & Society*, *11*(3), 97–113.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum.

- Commeyras, M. (1993). Promoting critical thinking through dialogical-thinking reading lessons. *The Reading Teacher*, *46*, 486–493.
- Cooper, J., & Weaver, K. D. (2003). *Gender and computers: Understanding the digital divide*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Cote, N., Goldman, S., & Saul, E. (1998). Students making sense of informational text: Relations between processing and representation. *Discourse Processes*, *25*, 1–53.
- Dautenhahn, K., Bond, A. H., Canamero, L., & Edmonds, B. (Eds.). (2002). *Socially intelligent agents: Creating relationships with computers and robots*. Norwell, MA: Kluwer Academic Publishers.
- Dempsey, J. V., & van Eck, R. (2003). Modality and placement of a pedagogical adviser in individual interactive learning. *British Journal of Educational Technology*, *34*(5), 585–600.
- Dunham, P. H. (1990). *Procedures to increase the entry of women in mathematics-related careers (Publication no. ED324195)*. Retrieved December 7, 2006, from <http://ericae.net/edo/ED324195.HTM>
- Gambrell, L. B. (2001). What we know about motivation to read. In R. F. Flippo (Ed.), *Reading Researchers in Search of Common Ground* (pp. 129–143). Newark, Delaware: International Reading Association.
- Gersten, R., Fuchs, L. S., Williams, J. P., & Baker, S. (2001). Teaching reading comprehension strategies to students with learning disabilities: A review of research. *Review of Educational Research*, *71*(2), 279–320.
- Graesser, A. C., Moreno, K. N., & Marineau, J. C. (2003, July). *AutoTutor improves deep learning of computer literacy: Is it the dialogue or the talking head?* Paper presented at the International Conference of Artificial Intelligence in Education, Sydney, Australia.
- Gulz, A. (2004). Benefits of virtual characters in computer-based learning environments: Claims and evidences. *International Journal of Artificial Intelligence in Education*, *14*, 313–334.
- Gulz, A. (2005). Social enrichment by virtual characters : Differential benefits. *Journal of Computer-Assisted Learning*, *21*, 405–418.
- Guthrie, J. T. (2002). Motivation and engagement in reading instruction. In M. Kamil, J. Manning & H. Walberg (Eds.), *Successful Reading Instruction* (pp. 137–154). Greenwich, CT: Information Age Publishing.
- Guthrie, J. T., Wigfield, A., Barbosa, P., Perencevich, K. C., Taboada, A., Marcia H. Davis, et al. (2004). Increasing reading comprehension and engagement through concept-oriented reading instruction. *Journal of Educational Psychology*, *96*(3), 403–423.
- Guthrie, J. T., Wigfield, A., & Humenick, N. M. (2006). Influences of stimulating tasks on reading motivation and comprehension. *The Journal of Educational Research*, *99*(4), 232–245.
- Haake, M., & Gulz, A. (2008). Visual stereotypes and virtual pedagogical agents. *Educational Technology & Society*, *11*(4), 1–15.
- Hakkarainen, K., & Palonen, T. (2003). Patterns of female and male students' participation in peer interaction in computer-supported learning. *Computers & Education*, *40*, 327–342.
- Iacobelli, F., & Cassell, J. (2007). Ethnic identity and engagement in embodied conversational agents. In J. G. Carbonell & J. Siekmann (Eds.), *Intelligent Virtual Agents* (pp. 57–63). Berlin: Springer.
- Johnson, W. L., Rickel, J. W., & Lester, J. C. (2000). Animated pedagogical agents: Face-to-face interaction in interactive learning environments. *International Journal of Artificial Intelligence in Education*, *11*, 47–78.
- Kegel, C. A. T., & Bus, A. G. (2012). Online tutoring as a pivotal quality of web-based early literacy programs. *Journal of Educational Psychology*, *104*(1), 182–192.
- Kim, Y. (2007). Learners' expectations of the desirable characteristics of virtual learning companions. *International Journal of Artificial Intelligence in Education*, *17*(4), 371–388.
- Kim, Y., & Baylor, A. L. (2007). Pedagogical agents as social models to influence learner attitudes. *Educational Technology*, *47* (01), 23–28.
- Kim, Y., Baylor, A. L., & Shen, E. (2007). Pedagogical agents as learning companions: The impact of agent gender and affect. *Journal of Computer-Assisted Learning* *23* (03), 220–234.
- Kim, Y., & Wei, Q. (2011). The impact of user attributes and user choice in an agent-based environment. *Computers & Education*, *56*, 505–514.

- Kim, Y., Wei, Q., Xu, B., & Ko, Y. (2007, April). *MathGirls: virtual peers as change agents to improve girls' math self-efficacy and math attitudes*. Paper presented at the Annual Conference of American Educational Research Association (AERA), Chicago, IL.
- Leopold, C., & Leutner, D. (2012). Science text comprehension: Drawing, main idea selection, and summarizing as learning strategies. *Learning and Instruction, 22*(1), 16–26.
- Mayer, R. E., Johnson, W. L., Shaw, E., & Sandhu, S. (2006). Constructing computer-based tutors that are socially sensitive: Politeness in educational software. *International Journal of Human-Computer Studies, 64*, 36–42.
- McNamara, D. S., & Kintsch, W. (1996). Learning from texts: Effects of prior knowledge and text coherence. *Discourse Processes, 22*, 247–288.
- McQuiggan, S. W., Robinson, J. L., & Lester, J. C. (2010). Affective transitions in narrative-centered learning environments. *Educational Technology & Society, 13*(1), 40–53.
- Moreno, R., & Mayer, R. E. (2000). Engaging students in active learning: The case for personalized multimedia messages. *Journal of Educational Psychology, 92*(4), 724–733.
- Moreno, R., Mayer, R. E., Spires, H. A., & Lester, J. C. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction, 19*(2), 177–213.
- National Institute for Literacy (2007). *What content-area teachers should know about adolescent literacy: The National Institute of Child Health and Human Development (NICHD)*. Retrieved April 7, 2011, from <http://lincs.ed.gov/publications/publications.html>.
- National Reading Panel (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups*. Bethesda, MD: National Institute of Child Health and Human Development.
- Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension fostering and monitoring activities. *Cognition and Instruction, 1*, 117–175.
- Passig, D., & Levin, H. (2000). Gender preferences for multimedia interfaces. *Journal of Computer Assisted Learning, 16*(1), 64–71.
- Pearson, P. D., & Dole, J. A. (1987). Explicit comprehension instruction: A review of research and a new conceptualization of instruction. *The Elementary School Journal, 88*(2), 151–165.
- Pinnell, G. S. (2002). The guided reading lesson: Explaining, supporting, and prompting for comprehension. In C. C. Block, L. B. Gambrell, & M. Pressley (Eds.), *Improving comprehension instruction: Rethinking research theory, and classroom practice* (pp. 106–134). San Francisco, CA: Jossey-Bass.
- Plant, E. A., Baylor, A. L., Doerr, C. E., & Rosenberg-Kima, R. B. (2009). Changing middle-school students' attitudes and performance regarding engineering with computer-based social models. *Computers & Education, 53*, 209–215.
- Pressley, M. (2002). Chapter 13: Metacognition and self-regulated comprehension. In A. E. Farstrup & S. Samuels (Eds.), *What research has to say about reading instruction* (pp. 291–309). Newark, DE: International Reading Association.
- Reeves, B., & Nass, C. (1996). *The Media Equation: How people treat computers, television, and new media like real people and places*. Cambridge, MA: Cambridge University Press.
- Rosenshine, B. V. (1986). Synthesis of research on explicit teaching. *Educational Leadership, 43*, 60–69.
- Ryokai, K., Vaucelle, C., & Cassell, J. (2003). Virtual peers as partners in storytelling and literacy learning. *Journal of Computer Assisted Learning, 19*(2), 195–208.
- Schunk, D. H., & Hanson, A. R. (1989). Influence of peer-model attributes on children's beliefs and learning. *Journal of Educational Psychology, 81*(3), 431–434.
- Spörera, N., Brunsteina, J. C., & Kieschkeb, U. (2009). Improving students' reading comprehension skills: Effects of strategy instruction and reciprocal teaching. *Learning and Instruction, 19*(3), 272–286.
- Stockwell, G. (2007). A review of technology choice for teaching language skills and areas in the CALL literature. *European Association for Computer Assisted Language Learning, 19*(2), 105–120.
- Trabasso, T., & Bouchard, E. (2002). Teaching readers how to comprehend text strategically. In C. C. Collins & M. Pressley (Eds.), *Comprehension instruction: Research-based best practices* (pp. 176–200). New York: Guilford Press.

van Keer, H., & Verhaeghe, J. P. (2005). Effects of explicit reading strategies instruction and peer tutoring on second and fifth graders' reading comprehension and self-efficacy perceptions. *The Journal of Experimental Education*, 73(4), 291–329.

Weber, K., & Custer, R. (2005). Gender-based preferences toward technology education content, activities, and instructional methods. *Journal of Technology Education*, 16(2), 55–69.

Wharton-McDonald, R., Pressley, M., & Hampston, J. M. (1998). Literacy instruction in nine first-grade classrooms: Teacher characteristics and student achievement. *The Elementary School Journal*, 99(2), 101–128.

Yun, S., Miller, P. C., Baek, Y., Jung, J., & Ko, M. (2008). Improving recall and transfer skills through vocabulary building in web-based second language learning: An examination by item and feedback type. *Educational Technology & Society*, 11(4), 158–172.